Contribution to the Dinoflagellate Flora of Ohio[1]

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ABSTRACT. Water samples were collected from over 100 sites in Ohio in a survey for dinoflagellates. Whole water and tows were taken from ponds, lakes, and reservoirs. Approximately half the samples contained dinoflagellates and 24 taxa were identified including 13 not previously reported from Ohio. New taxa include *Ceratium brachyceros*, *Peridinium umbonatum*, *Peridinium volzii*, *Thompsodinium intermedium*, *Peridiniopsis cunningtonii*, *Cystodinedria inermis*, *Gymnodinium austriacum*, *G. hiemale*, and *G. wawrikae*. Four of the published forms of *Ceratium hirundinella* were recognized including forma *silesiacum*, forma *piburgense*, forma *scotticum*, and forma *gracile*.

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INTRODUCTION

Ohio is fortunate to have many studies of its algal flora, some on diatoms, some on desmids and Chlorophyta, and some surveys of floras in particular habitats (Taft 1973, Collins and Kalinsky 1977, Stuckey 1990). No Ohio studies have specifically sought and identified dinoflagellates, and some species reports (Table 1) are doubtful since there are no sketches, photographs, or measurements accompanying the identifications.

Dinoflagellates are a distinctive group of unicellular protists recognized by their swimming pattern (spinning while advancing due to transverse and longitudinal flagella), golden-brown pigmentation, large centrally located nucleus with permanently condensed chromosomes, and median constriction (the cingulum). Dinoflagellates can be divided into two groups: those with a cellulose wall divided into plates ("armored"), and those apparently lacking a rigid wall ("naked"). The identity of armored dinoflagellates must be confirmed by the tabulation of their plates; however, certain key features can be recognized in some species which aid in their identification. For general information about dinoflagellates consult Popovsky and Pfiester (1990) or Spector (1984). The objective of the present study is to report on dinoflagellate collections throughout the state and provide species descriptions which will be useful to individuals working with phytoplankton samples.

MATERIALS AND METHODS

Samples were collected from ponds, lakes, and reservoirs as whole water, plankton tows, and squeezings from marginal vegetation. Most collections were made between June and October 1992. Duplicate samples were collected, one to be examined immediately upon return to the laboratory, the second preserved with Lugol's iodine (Throndsen 1978). Water temperature and pH were recorded from collection sites. Line drawings were based on sketches made during observations and from micrographs. Light micrographs were made using a Wild M12 compound microscope with Kodak black and white film (TMAX 100 and 400, Tri-X pan 400, Plus X pan 125).

TABLE 1

Dinoflagellates previously reported from Ohio.

Taxon	Reference(s)
Armored	
Ceratium cornutum	Salisbury 1931
Ceratium hirundinella	Budd 1971, Frederick 1974, Rathke 1979, Ross 1974, Taft and Taft 1971
Diplosalis acuta (1)	Taft and Taft 1971
Glenodinium aciculiferum (2)	Salisbury 1931, Taft and Taft 1971
Gl. borgei (3)	Budd 1971
Gl. gymnodinium (4)	Salisbury 1931
Gl. kulczynskii (5)	Frederick 1974
Gl. pulvisculus (6)	Taft and Taft 1971, Budd 1971
Gl. quadridens (7)	Budd 1971, Briggs 1972, Frederick 1974, Ross 1974, Moore 1976
Peridinium aciculiferum	Rathke 1979
P. bipes	Davidson 1932
P. cinctum	Budd 1971, Briggs 1972, Frederick 1974, Ross 1974, Moore 1976
P. gatunense	Sweitzer 1971
P. inconspicuum	Steinback 1966
P. quadridens (7)	Shawver 1931, Mason 1938, Taft and Taft 1971, Klarer 1985, Salisbury 1931
P. tabulatum	Salisbury 1931
P. willei	Budd 1971, Frederick 1974, Sweitzer 1971
P. wisconsinense	Mason 1938, Budd 1971
Naked	
Cystodinium bataviense	Taft and Taft 1971, Ross 1974
C. iners	Taft and Taft 1971
Gloeodinium montanum	Taft and Taft 1971
Gymnodinium acidotum	Klarer 1985
Gymnodinium aeruginosum	Taft and Taft 1971
G. helveticum	Rathke 1979, Klarer 1985
G. palustre	Budd 1971
Hemidinium nasutum	Taft and Taft 1971
Hypnodinium sphaericum	Taft and Taft 1971
Stylodinium globosum	Taft and Taft 1971
Tetradinium javanicum	Taft and Taft 1971

Nomenclatural changes: (1) *Entzia acuta*. (2) *Peridinium aciculiferum*. (3) *Peridiniopsis borgei*. (4) *Peridiniopsis polonicum*. (5) *Peridiniopsis kulczynskii*. (6) no known plate tabulation, unknown genus. (7) *Peridiniopsis quadridens*.

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Species identifications were made using the works of Lefèvre (1932), Starmach (1974), and Popovsky and Pfiester (1990).

RESULTS AND DISCUSSION

Dinoflagellate cells are considered to have a front (ventral, recognized by the presence of the sulcal groove) and back (dorsal) surface; the mid-cell cingulum (groove containing the transverse flagellum) divides the cell into an upper portion (epitheca, epicone) and lower portion (hypotheca, hypocone). Thus, the cell may be viewed from four directions: ventral, dorsal, apical, and antapical. Thecate, or armored, dinoflagellates have a cellulose wall divided into plates and their taxonomy is based on the number and arrangement of the plates. Kofoid (1909) proposed a numbering system for the plates which are often in concentric rows above and below the cingulum. The first, most ventral, plate in a series is the one plate; plates are numbered counterclockwise. The series of plates closest to the apex is designated apical and has a single prime (') mark after the number. Precingular plates have two prime following the number, postcingular three prime, and antapical four prime. Plates between the apical and precingular series are anterior intercalary (a), and plates between postcingular and antapical series are posterior intercalary (p). Plate tabulations are always included in species descriptions (e.g., 4', 3a, 7", 5"', 2"" for *Peridinium cinctum*). Non-thecate, or naked, dinoflagellates lack a cellulose wall and their taxonomy is based on shape, pigmentation, presence of an eyespot (stigma), and motility. The current study identified 24 taxa: 16 armored, and eight naked, of which 13 are new records for the state (Table 2). Most of the taxa recorded here have distinctive features which facilitate their identification.

A Key to the Easy-to-Identify Dinoflagellates in Ohio: A Preliminary Key Based on Work in Progress

This key is based only on the species of dinoflagellate found by the author and does not include all previously reported species. A number of species (perhaps 30% of the common flora, 50% of the total flora) will not key using this key. Work is in progress on additional species.

1. Cell with rigid outer wall, motile, yellow, golden, or brown chloroplasts (thecate dinoflagellates) 2
1. Cell lacking rigid outer wall, motile or non-motile, pigmented or not (non-thecate dinoflagellates) 13
2. Cell body extended into three or four horns composed of plates 3
2. Cell body round to oval/elliptical in ventral view 4
3. Hypothecal horns two, short . . . . *Ceratium brachyceros*
3. Hypothecal horns two or three, slender . . . . *Ceratium hirundinella*
4. Hypotheca with spines, apical pore present 5
4. Hypotheca without spines 9
5. A single stout spine at antapex . . . . *Peridiniopsis polonicum*
5. Short spines extend from postcingular and antapical plates 6
6. Cell 28-38 μm long, apex extended and truncate 7
6. Cell 18-27 μm long, apex rounded 8
7. Plate pattern 5', 1a, 7", 5"', 2"" . . . . *Peridiniopsis quadridens*
7. Plate pattern 5', 0a/4', 1a, 6", 5"', 2"" . . . . *Peridiniopsis cunningtonii*
8. Cell about 2/3 epitheca, 1/3 hypotheca, ovoid . . . . *Peridinium umbonatum*
8. Cell about 1/2 epitheca, 1/2 hypotheca, pentagonal . . . . *Peridinium inconspicuum*
9. Cell with apical pore 10
9. Cell without apical pore 11
10. Plate pattern 4', 3a, 7", 5"', 2"", plates thick . . . . *Peridinium bipes*
10. Plate pattern 4', 3a, 6", 5"', 2"", plates thin . . . . *Thompsodinium intermedium*
11. Cell round in cross section, lumpy in ventral view . . . . *Peridinium gatunense*
11. Cell dorsoventrally compressed 12
12. Cell with distinctive flanges extending from cingular and apical plate margins, common . . . . *Peridinium willei*
12. Cells without distinctive flanges, uncommon . . . . *Peridinium volzii*
13. Cell free floating or attached 14
13. Cell motile 17
14. Cell free floating, brown cell inside elliptical case . . . . *Cystodinium bataviense*
14. Cell attached 15
15. Oval cell directly appressed to host cell . . . . *Cystodinedria iners*
15. Cell on long or short stalk 16
16. Round cell at end of long stalk, colorless . . . . *Stylodinium globosum*
16. Tetragonal brownish cell with spines at corners, on a short stalk . . . . *Tetradinium javanicum*
17. Cell with pigmented chloroplasts 18
17. Cell without chloroplasts, may have colored accumulation bodies 19
18. Cell bluegreen . . . . *Gymnodinium acidotum*
18. Cell brownish . . . . *Gymnodinium wawrikae*
19. Cell large, 32-40 μm long, sulcus extending almost to apex and antapex . . . . *Gymnodinium austriacum*
19. Cell 16-21 μm long, mushroom shaped . . . . *Gymnodinium hiemale*

Ceratium Shrank 1793

Freshwater *Ceratium* is characterized by one apical, one antapical, and one or two postcingular horns. Species are distinguished by either a curved (*C. carolineanum*, *C. cornutum*) or a straight (*C. hirundinella*) apical horn. Cells are golden yellow with thick plates displaying reticulate ornamentation; plate pattern is 4', 5", 5"', 2"". Total lengths reported here are from the apex of the apical horn to the point of the antapical horn.

Ceratium brachyceros Daday 1907 (Figs. 1, 25, 26) is a short, stubby species with a conical epitheca, apical horn smoothly tapered from the body, and one, short, downward pointing postcingular horn. It was found throughout the state though less commonly than *Ceratium hirundinella*. Length 78-140 μm, width 43 μm.

Ceratium hirundinella (O. F. M.) Bergh 1882 is a large,

TABLE 2

Dinoflagellates found during this study.

Taxon	Location of Collecting Site**
Armored	
*Ceratium brachyceros**	4, 6, 15, 23, 24, 36
Ceratium hirundinella f. *hirundinella*	1, 17, 33, 45
f. *piburgense**	9, 11, 17, 25, 27, 29, 32, 34, 39, 43
f. *gracile**	44
f. *scotticum**	23
f. *silesiacum**	14, 42
Peridinium bipes	35
P. gatunense	5, 8, 14, 19, 21, 32, 35, 37, 38, 39, 40
P. inconspicuum	12, 20, 23, 26
*P. umbonatum**	10, 16, 41
*P. volzii**	10
P. willei	10, 19, 24, 25, 31, 33, 40
*Peridiniopsis cunningtonii**	2
Per. polonicum	2, 10, 16, 18, 23
Per. quadridens	7, 13, 16
*Thompsodinium intermedium**	36
Naked	
*Cystodinedria inermis**	35
Cystodinium bataviense	35
Gymnodinium acidotum	3, 6, 22
*G. austriacum**	41
*G. hiemale**	28
*G. wawrikae**	30
Stylodinium globosum	35
Tetradinium javanicum	10

*New report for Ohio.

**Collecting sites where dinoflagellates were found: (COUNTY *Town*: site, location, number). ASHLAND *Bailey Lake*: Bailey Lake (1). DELAWARE *Delaware*: Alum Creek at marina (2), Delaware Reservoir at marina (3). ERIE *Castalia*: Resthaven Wildlife Area (4), school pond on SR101 (5). FRANKLIN *Westerville*: Hoover Reservoir, marina near dam (6). HANCOCK *Fostoria*: L. Lumberjack (7). HURON *New London*: New London Reservoir (8), *Willard*: Willard Reservoir (9). LORAIN *Oberlin*: Hozalski bog, Gore Orphanage Rd (10), *Wellington*: Findley Lake, Findley State Park (11). LUCAS *Holland*: Eber Rd and Industrial (12), Obee Rd (13), *Whitehouse*: quarry (14). MAHONING *Austintown*: Meander Reservoir (15), Lake Milton at Talmadge Rd (16). PREBLE *Eaton*: Lakengren area lakes: Kastrup (17), Lakengren (18), Bear (19); John Deere store pond, US 127 (20), Dixon Rd pond (21) *Camden*: Paint Creek quarry (22). RICHLAND *Bellville*: Roberts Lake, Bellville-Johnsville Rd (23), *Lexington*: Clear Fork Reservoir near dam (24), quarry pond on SR97 near I71 (25). SANDUSKY Miller's Blue Hole US6 (26), *Clyde*: Raccoon Reservoir (27), *Fremont*: cemetery pond on SR53 (28). SENECA *McCutchenville*: Frey farm TR117 (29), Romig pond (30), Collier pond, TR26 (31), Weininger pond, CR58 (32), *Green Springs*: Stonebreaker farm (33), Beaver Creek Reservoir (34), *Springville*: marsh (35), *Tiffin*: pond at jct US224 and SR231 (36). STARK *Wilmot*: Wilderness L., Wilderness Center (37), *Louisville*: gravel pit, Essroc Materials (38), Constitution Park pond (39), Snyder farm, Columbus Rd (40). WAYNE *Shreve*: Brown L. Bog (41), Elyria Rd pond at RR crossing (42). WILLIAMS *Pioneer*: L. Wooduck (43), L. Mel (44). WOOD *North Baltimore*: Millers quarry pond, Eagleville Rd (45).

distinctive phytoplankter and the most commonly reported freshwater dinoflagellate. This species is distinguished from *C. brachyceros* by the presence of "shoulders" in *C. hirundinella*, the apical horn is distinct from the body.

Ceratium hirundinella is recognized as having different forms (Huber-Pestalozzi 1950, Hutchinson 1967) varying in the number of postcingular horns, their directions and proportions. Some of these forms have attained species status and the status of other forms remains in question. *Ceratium hirundinella* was found throughout the state in the summer, sometimes in bloom condition.

Ceratium hirundinella forma *hirundinella* (Figs. 2, 27) is recognized by its long straight apical horn, and usually two, outward pointing postcingular horns. Length 188-247 μm.

Ceratium hirundinella forma *piburgense* (Figs. 3, 28) has a smaller body volume than the type form; the body abruptly tapers to form the apical horn. The postcingular horns are long, approximately equal in length, and splayed. The antapical horn is abruptly contracted to form the horn, looking somewhat like a peg-leg. Length 210-322 μm.

Ceratium hirundinella forma *silesiacum* (Figs. 4, 29) has one, inward curving postcingular horn. Length 186-208 μm.

Ceratium hirundinella forma *scotticum* (Fig. 5) has two short, approximately equal, outward spreading postcingular horns. Length 183 μm.

Ceratium hirundinella forma *gracile* (Figs. 6, 30) has one or two downward pointing postcingular horns. It is similar to forma *hirundinella*, differing in the direction of horns. Length 168-257 μm.

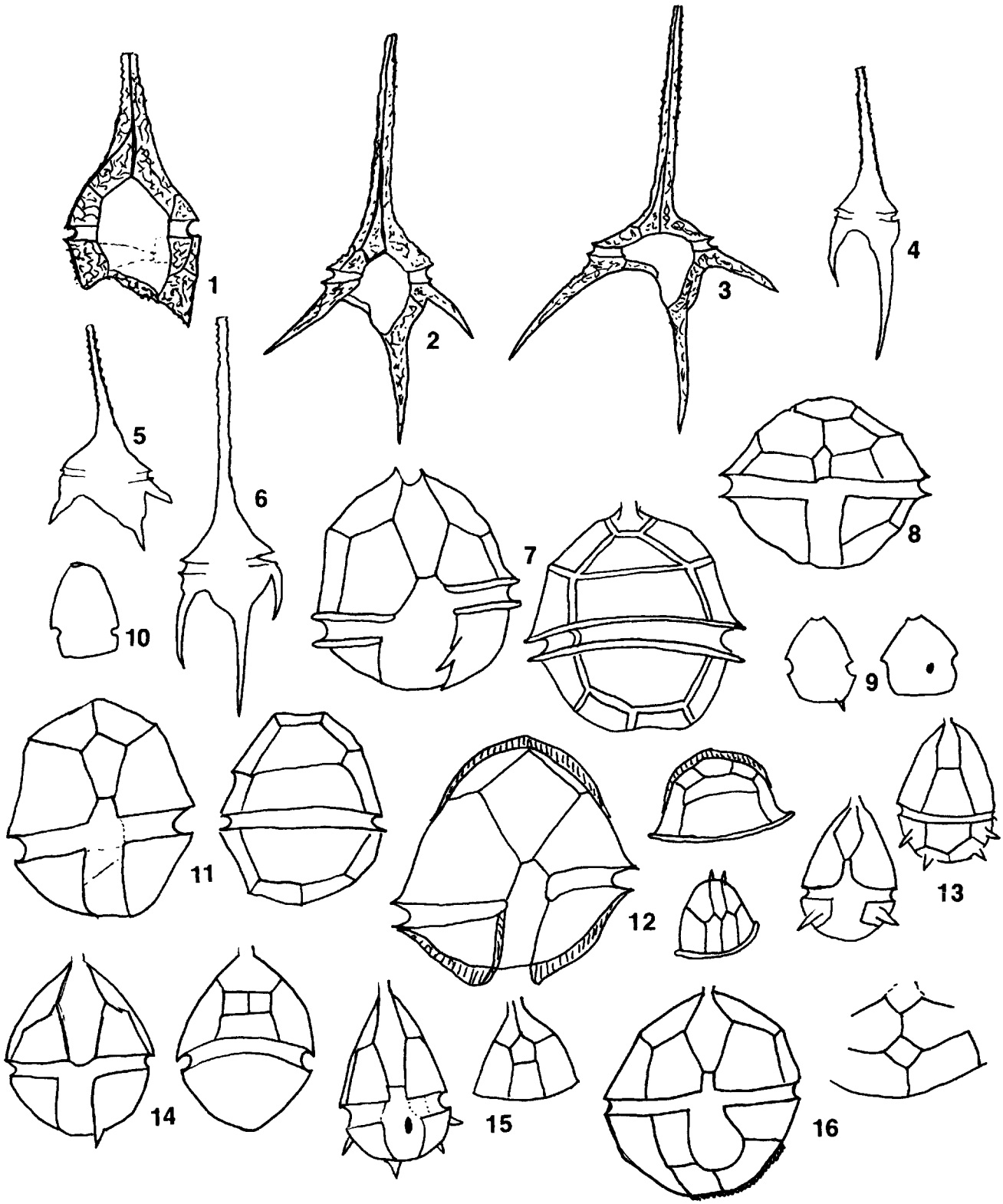
Peridinium Ehrenberg 1830

Peridinium is defined by its plate tabulation formula 4', 2-3a, 7", 5‴, 2⁗. Species differ in the number of intercalary plates, apical symmetry, and the presence or absence of an apical pore. Most species are found as minor components of the phytoplankton although occasionally one species will completely dominate a pond or lake.

Peridinium bipes Stein 1883 (Figs. 7, 31) has an apical pore, its cingulum is offset a cingulum width, and it is ventrally concave. Our specimens lack the typical paired antapical flanges. It looks like a *P. willei* with an apical pore; its plate pattern is 4', 3a, 7", 5‴, 2⁗. Length 67 μm, width 64 μm.

Peridinium gatunense Nygaard 1925 (Figs. 8, 32) is a golden to dark brown cell, described as "humpbacked"; it is round in apical or antapical view (i.e., no dorsoventral compression), and wider than long. Some cells have red accumulation bodies. Its apical and intercalary plates are in an asymmetrical arrangement and there is no apical pore; plate pattern is 4', 3a, 7", 5‴, 2⁗. It was common throughout the state, sometimes found in bloom condition. Length 67.5 μm, width 52-65 μm.

Peridinium inconspicuum Lemmermann 1899 (Figs. 9, 33) is a small, approximately pentagonal cell with an apical pore, yellow-gold chloroplasts, and an approximately equatorial cingulum. Cells may have hypothecal spines; plate pattern is 4', 2a, 7", 5‴, 2⁗. Length 18.5-22 μm, width 15.5-19.5 μm.



FIGURES 1-16. Sketches of armored dinoflagellates. Fig. 1. *Ceratium brachyceros*, ventral view. Fig. 2. *Ceratium hirundinella* forma *hirundinella*, ventral view. Fig. 3. *Ceratium hirundinella* forma *piburgense*, ventral view. Fig. 4. *Ceratium hirundinella* forma *silesiacum*, ventral view. Fig. 5. *Ceratium hirundinella* forma *scotticum*. Fig. 6. *Ceratium hirundinella* forma *gracile*. Fig. 7. *Peridinium bipes*, ventral and dorsal views. Fig. 8. *Peridinium gatunense*, ventral view. Fig. 9. *Peridinium inconspicuum*, two outlines. Fig. 10. *Peridinium umbonatum*, outline. Fig. 11. *Peridinium volzii*, ventral and dorsal views. Fig. 12. *Peridinium willei*, ventral, dorsal epitheca, side. Fig. 13. *Peridiniopsis cunningtonii*, ventral and dorsal views. Fig. 14. *Peridiniopsis polonicum*, ventral and dorsal views. Fig. 15. *Peridiniopsis quadridens*, ventral, dorsal epitheca. Fig. 16. *Thompsodinium intermedium*, ventral, dorsal epitheca.

Peridinium umbonatum Stein 1883 (Figs. 10, 34), like *P. inconspicuum*, is a small cell, but it has a broadly rounded epitheca, and its cingulum divides the cell into approximately 2/3 epitheca, and 1/3 hypotheca. There is

an apical dimple indicating the presence of a pore; plate pattern is 4', 2a, 7'', 5''', 2''''. Length 20-27 μm, width 14-21 μm.

Peridinium volzii Lemmermann 1906 (Fig. 11) has a plate pattern similar to *P. willei* with apical intercalary plates in a symmetrical arrangement, but the cell is less compressed, and the plates are larger and lack flanges. The cells are round in ventral view, somewhat dorsoventrally compressed, with a defined sulcus reaching the antapex, and thick plates with reticulate ornamentation; plate pattern is 4', 3a, 7'', 5''', 2''''. Length 42-50 μm, width 35-44.5 μm.

Peridinium willei Huitfeld-Kaas 1900 (Figs. 12, 35) is a fairly large, golden brown species with distinctive flanges extending from apical plate boundaries, cingulum, and posterior borders, no stigma, concave ventral surface, and large 1' plate. Its apical and intercalary plates are in a symmetrical arrangement and there is no apical pore, plate pattern is 4', 3a, 7'', 5''', 2''''. It was found fairly commonly throughout the state. Length 48-58 μm, width 49-52 μm.

Peridiniopsis Lemmermann 1904

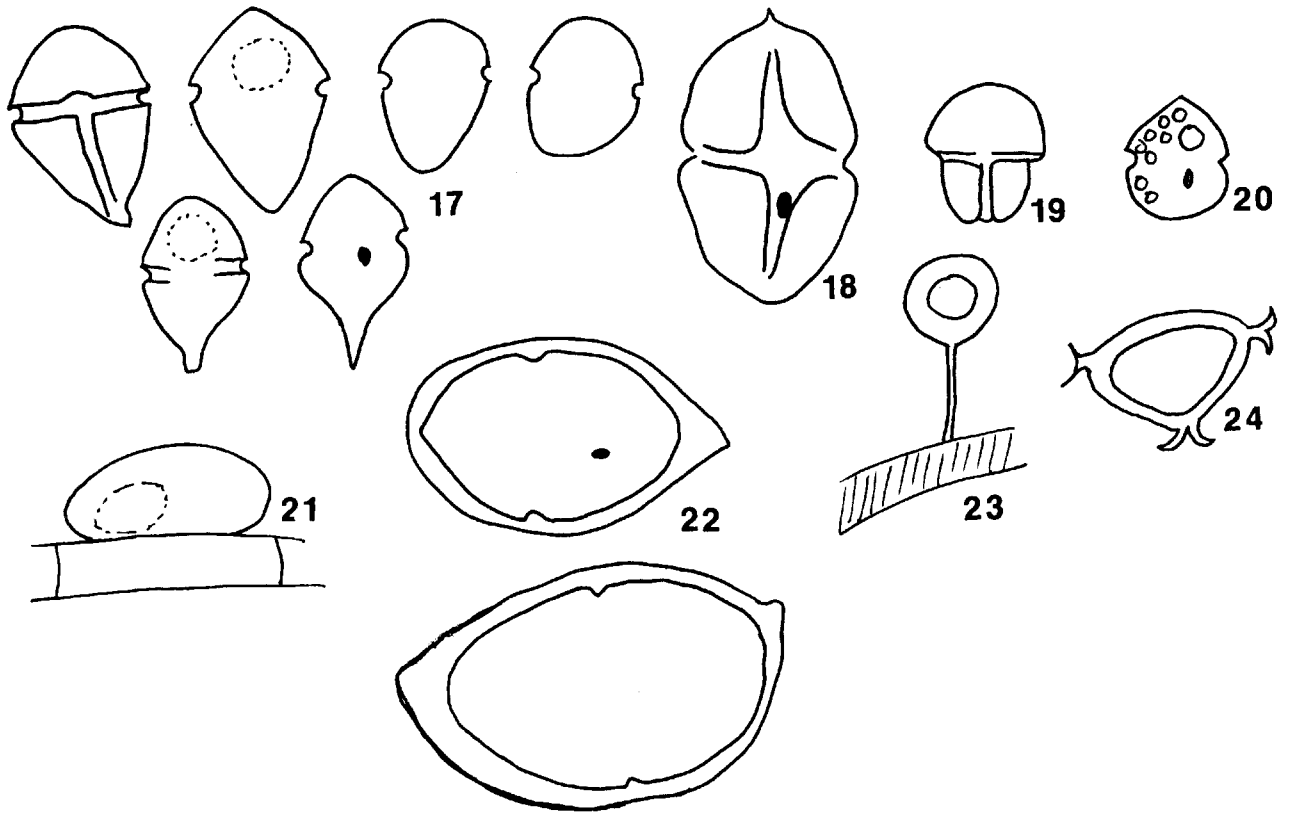
Bourrelly (1968) transferred species of *Glenodinium* with known plate tabulations into the genus *Peridiniopsis*; it remains a highly variable genus (3-5', 0-1a, 6-7'', 5''', 2'''').

Peridiniopsis cunningtonii Lemmermann 1907 (Fig. 13) is similar to *Peridiniopsis quadridens* (see Carty 1989 for comparison), and plates are necessary for positive identification. The plate pattern is 5', 0a, (or 4', 1a), 6'', 5''', 2''''', with spines on 1''', 2''', 4''', and 5'''. Length 38 μm.

Peridiniopsis polonicum (Woloszynska) Bourrelly 1968 (Figs. 14, 36) can be recognized by its conical epitheca and rounded hypotheca, dorsoventral compression, apical pore with surrounding ridges, broad sulcus with parallel sides to the antapex, and thick spine at the terminus of the sulcus on the left side. The plate pattern is 4', 2a, 7'', 5''', 2''''. Length 41.6-52 μm, width 37-39 μm.

Peridiniopsis quadridens (Stein) Bourrelly 1968 (Figs. 15, 37) is ovoid in shape, with some dorsoventral compression; it has golden chloroplasts, its apex is extended and truncate, and there are four spines extending from hypothecal plates. If plates can be seen, a 1a plate lies over the 4'', plate pattern 5', 1a, 7'', 5''', 2''''. Length 28-30 μm, width 20-22 μm.

Thompsodinium intermedium (Thompson) Bourrelly 1970 (Figs. 16, 38) cells are almost round in ventral view, and plate tabulation is necessary for identification. Distinctive plate features include apical pore ridges, oval sulcus not reaching the antapex, antapical plates with fine teeth subtending the sulcus, large postcingular plates, small 4-5 sided 2a plate in middorsal epitheca, star shaped configuration of apical and intercalary plates around the apex, and fairly deep penetration of the sulcus into the epitheca; plate pattern 4', 3a, 6'', 5''', 2''''.



FIGURES 17-24. Sketches of naked dinoflagellates. Fig. 17. *Gymnodinium acidotum*, six cells. Fig. 18. *Gymnodinium austriacum*. Fig. 19. *Gymnodinium hiemale*. Fig. 20. *Gymnodinium wawrikae*. Fig. 21. *Cystodinedria inermis*. Fig. 22. *Cystodinium bataviense*, two cells. Fig. 23. *Stylodinium globosum*. Fig. 24. *Tetradinium javanicum*.

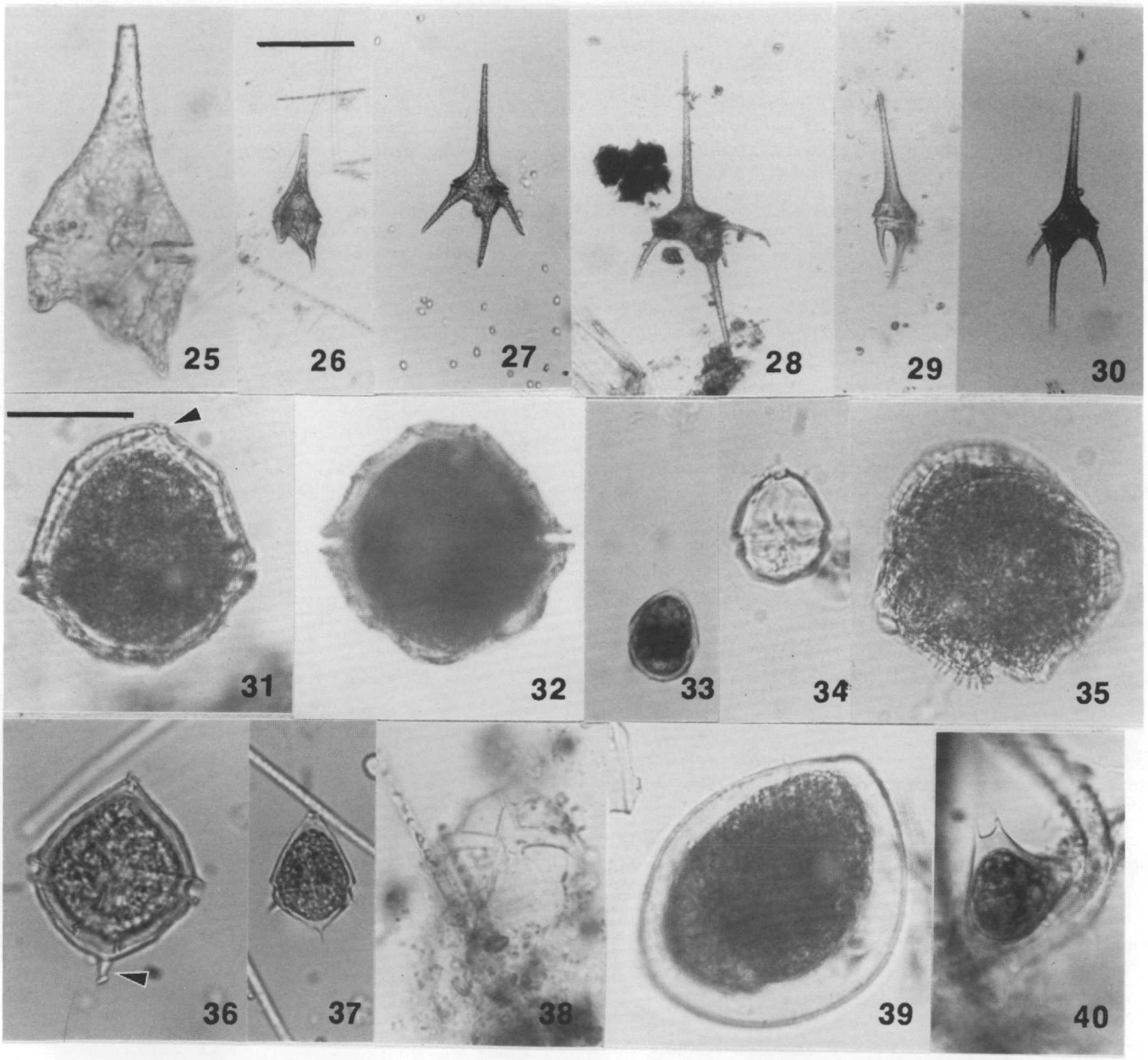
Gymnodinium Stein 1878

Gymnodinium is a genus of naked dinoflagellates with the cingulum in a median position. They must be examined and sketched while alive and swimming, because upon death they form featureless spheres (a useful way to distinguish *Gymnodinium* from thin walled *Glenodinium/Peridiniopsis* and *Woloszynskia*). The species are differentiated by the shape of the epicone and hypocone, details of the sulcus, presence of a stigma, and color. Species may be photosynthetic with yellow-gold or bluegreen chloroplasts, or they may be non-photosynthetic and colorless, or they may have accumulation bodies of various colors (yellow, orange, red).

Gymnodinium acidotum Nygaard 1949 (Fig. 17) has distinctive blue green chloroplasts, conical epicone, and hypocone tapered with a truncate process; some cells have a red stigma. It was found in bloom condition. Length 30-39 μm, width 15-23 μm.

Gymnodinium austriacum Schiller 1933 (Fig. 18) is a fairly large, non-photosynthetic *Gymnodinium* with a noticeable sulcus extending almost to the apex and to the antapex, forming a cross with the cingulum; cells contained colored inclusion bodies, and a stigma. Length 32.5-40.3 μm, width 31.2 μm.

Gymnodinium hiemale (Schiller) Popovsky 1984 (Fig. 19) is a non-photosynthetic species, its sulcus extends to



FIGURES 25-40. Light micrographs of dinoflagellates. Micrographs 25, 31-40 were taken at 40X, 26-30 at 10X; scale bar equals 100 μm at 10X, 30 μm at 40X. Fig. 25. *Ceratium brachyceros.* Fig. 26. *Ceratium brachyceros.* Fig. 27. *Ceratium hirundinella* forma *hirundinella.* Fig. 28. *Ceratium hirundinella* forma *piburgense.* Fig. 29. *Ceratium hirundinella* forma *silesiacum.* Fig. 30. *Ceratium hirundinella* forma *gracile.* Fig. 31. *Peridinium bipes,* note apical pore. Fig. 32. *Peridinium gatunense.* Fig. 33. *Peridinium inconspicuum.* Fig. 34. *Peridinium umbonatum.* Fig. 35. *Peridinium willei.* Fig. 36. *Peridiniopsis polonicum,* note antapical spine. Fig. 37. *Peridiniopsis quadridens.* Fig. 38. *Thompsodinium intermedium.* Fig. 39. *Cystodinium bataviense.* Fig. 40. *Tetradinium javanicum.*

the antapex, the nucleus is in the hypocone, and there may be red inclusion bodies. Ohio specimens are larger (length 21 μm) than those described in the literature (up to 16 μm)

Gymnodinium wawrikae Schiller 1955 (Fig. 20) is a photosynthetic species with golden chloroplasts, its epicone is conical and slightly larger than the broadly rounded hypocone; the cingulum is approximately median, without displacement, and there is a stigma present. Length 24-26 μm, width slightly less.

Cystodinedria inermis (Geitler) Pascher 1944 (Fig. 21) is a parasitic taxon, approximately oval except for flattening where it is appressed to a host cell. It may be recognized by its golden coloration and large nucleus. Cells were found on filaments of *Oedogonium.* All species were synonymized by Popovsky and Pfiester (1990). Length 48 μm, width 32 μm.

Cystodinium bataviense Klebs 1912 (Figs. 22, 39) is a large, ovoid cell; it can be recognized as a dinoflagellate by the large, golden-brown *Gymnodinium*-like cell with median cingulum and red stigma found within the outer membrane. The outer membrane is asymmetrical, with one end having a nipple-like extension. Length (overall) 65-108 μm, width 52-58.5 μm.

Stylodinium globosum Klebs 1912 (Fig. 23) is a parasitic taxon. The spherical cell is attached to the host by a slender, colorless stalk. It may be recognized as dinoflagellate by the large centrally located nucleus. All species were synonymized by Popovsky and Pfiester (1990). Total length (with stipe) 32.75 μm, cell length 20 μm, width 17.5 μm.

Tetradinium javanicum Klebs 1912 (Figs. 24, 40) does not look like a dinoflagellate at all, though it does have the golden pigmentation one associates with dinoflagellates. It is an attached genus with a plump body drawn out into four, two-spined angles. Length 27 μm, width 30.4 μm.

The presence of dinoflagellates, other than that of *Ceratium hirundinella*, is probably under-reported in the literature because of both the inherent difficulty in identifying genera and species, and an old and scattered literature. Armored dinoflagellates require elucidation of the plate pattern and comparison to reported patterns. Naked dinoflagellates require immediate examination. During this study other taxa with thin thecae were found but not identified because of insufficient material and lack of definitive characteristics. Additional contributions to the dinoflagellate flora of Ohio are planned.

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